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MOTOROLA

Embedded SDK (Software Development Kit)

Noise Suppression Library

SDK149/D
Rev. 1, 07/22/2002

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Contents

About This Document

Audience ix
Organization ix
Suggested Reading ix
Conventions x
Definitions, Acronyms, and Abbreviations x
References xi

Chapter 1
Introduction

1.1 Quick Start 1-1
1.2 Overview of Noise Suppression 1-1
1.2.1 Background 1-1
1.2.2 Features and Performance 1-2

Chapter 2
Directory Structure

2.1 Required Core Directories 2-1
2.2 Optional (Domain-Specific) Directories 2-2

Chapter 3
Noise Suppression Library Interfaces

3.1 Noise Suppression Services 3-1
3.2 Interface 3-1
3.3 Specifications 3-4
3.3.1 nsCreate 3-5
3.3.2 nsInit 3-9
3.3.3 nsProcess 3-12
3.3.4 nsDestroy 3-13

Chapter 4
Building the Noise Suppression Library

4.1 Building the Noise Suppression Library 4-1
4.1.1 Dependency Build 4-1
4.1.2 Direct Build 4-2

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Chapter 5
Linking Applications with the Noise Suppression Library

5.1 Noise Suppression Library 5-1
5.1.1 Library Sections 5-1

Chapter 6
Noise Suppression Applications

6.1 Test and Demo Applications. 6-1

Chapter 7
License

7.1 Limited Use License Agreement 7-1

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List of Tables

Table 3-1 nsCreate Arguments 3-5
Table 3-2 nsInit Arguments. 3-9
Table 3-3 nsProcess Arguments 3-12
Table 3-4 nsDestroy Arguments 3-13

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List of Figures

Figure 1-1 Functional Blocks of Noise Suppression library 1-2
Figure 2-1 Core Directories 2-1
Figure 2-2 Telephony Directory Structure 2-2
Figure 2-3 ns Directory Structure 2-3
Figure 2-4 Noise Suppression Application 2-4
Figure 4-1 Dependency Build for the Noise Suppression Library 4-1
Figure 4-2 ns.mcp Project 4-2
Figure 4-3 Execute Make 4-3

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List of Examples

Code Example 3-1 C Header File ns.h 3-1
Code Example 3-2 mem Library 3-5
Code Example 3-3 Use of the nsCreate Interface 3-7
Code Example 3-4 Sample Callback Procedure 3-10
Code Example 3-5 Use of nsInit Interface. 3-10
Code Example 5-1 linker.cmd File 5-1

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About This Document

This manual describes the Noise Suppression algorithm for use with Motorola's Embedded Software Development Kit, (SDK).

Audience

This document targets software developers implementing noise suppression functions within software applications.

Organization

This manual is arranged in the following sections:

- **Chapter 1, Introduction**—provides a brief overview of this document
- **Chapter 2, Directory Structure**—provides a description of the required core directories
- **Chapter 3, Noise Suppression Library Interfaces**—describes Noise Suppression Library functions
- **Chapter 4, Building the Noise Suppression Library**—tells how to execute the system library project build
- **Chapter 5, Linking Applications with the Noise Suppression Library**—describes organization of the Noise Suppression Library
- **Chapter 6, Noise Suppression Applications**—describes the use of Noise Suppression Library through test/demo applications
- **Chapter 7, License**—provides the license required to use this product

Suggested Reading

We recommend that you have a copy of the following references:

- *DSP56852 Family Manual*, DSP56852FM/AD
- *DSP568xx User's Manual* for the DSP device you're implementing
- *Inside CodeWarrior: Core Tools*, Metrowerks Corp.

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Conventions

This document uses the following notational conventions:

Typeface, Symbol or Term	Meaning	Examples
`Courier Monospaced Type`	Commands, command parameters, code examples, expressions, datatypes, and directives	...`*Foundational include files`... ...a data structure of type `vad_tConfigure`...
Italic	Calls, functions, statements, procedures, routines, arguments, file names and applications	...the *pConfig* argument... ...defined in the C header file, *aec.h*... ...makes a call to the *Callback* procedure...
Bold	Reference sources, paths, emphasis	...refer to the **Targeting DSP56852 Platform** manual.... ... see: **C:\Program Files\Motorola\Embedded SDK\help\tutorials**
Bold/Italic	Directory name, project name	...and contains these core directories: ***applications*** contains applications software.... ...CodeWarrior project, ***ns.mcp***, is.....
Blue Text	Linkable on-line	...refer to **Chapter 7**, License
Number	Any number is considered a positive value, unless preceded by a minus symbol to signify a negative value	3V -10 DES^{-1}
ALL CAPITAL LETTERS	Variables, directives, defined constants, files libraries	INCLUDE_DSPFUNC #define INCLUDE_STACK_CHECK
Brackets [...]	Function keys	...by pressing function key [F7]...
Quotation marks "... "	Returned messages	...the message, "Test Passed" is displayed.... ...if unsuccessful for any reason, it will return "NULL"....

Definitions, Acronyms, and Abbreviations

The following list defines the acronyms and abbreviations used in this document. As this template develops, this list will be generated from the document. As we develop more group resources, these acronyms will be easily defined from a common acronym dictionary. Please note that while the acronyms are in solid caps, terms in the definition should be initial capped ONLY IF they are trademarked names or proper nouns.

API Application Programming Interface

COM1 Communication Port 1

DSP Digital Signal Processor or Digital Signal Processing

EVM Evaluation Module

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FFT	Fast Fourier Transforms
FIR	Finite Impulse Response
HPF	High-Pass Filter
I/O	Input/Output
IDE	Integrated Development Environment
IFFT	Inverse Fast Fourier Transform
IIR	Infinite Impulse Response
IRQA	Interrupt Request A
MAC	Multiply/Accumulate
MIPS	Million Instructions Per Second
MSB	Most Significant Bit
NS	Noise Suppression
OnCE™	On-Chip Emulation
OMR	Operating Mode Register
PC	Program Counter
SDK	Software Development Kit
SNR	Signal-to-Noise Ratio
SP	Stack Pointer
SPI	Serial Peripheral Interface
SR	Status Register
SRC	Source

References

The following sources were used to produce this book:

1. *DSP56852 Family Manual*, DSP56852FM/AD
2. *DSP568xx User's Manual*
3. *Embedded SDK Programmer's Guide*

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Chapter 1
Introduction

Welcome to Motorola's Family of Digital Signal Processors (DSPs). This document describes the Noise Suppression Library, which is a part of Motorola's comprehensive Embedded Software Development Kit (SDK) for its DSPs. In this manual, you will find all the information required to use and maintain the Noise Suppression Library interface and algorithms.

Motorola provides these algorithms to you for use on Motorola DSPs to expedite your application development and reduce the time it takes to bring your own products to market.

Motorola's Noise Suppression Library is licensed for your use on Motorola processors. Please refer to the standard Software License Agreement in **Chapter 7** for license terms and conditions; please consult with your Motorola representative for premium product licensing.

1.1 Quick Start

Motorola's Embedded SDK is targeted to a large variety of hardware platforms. To take full advantage of a particular hardware platform, use **Quick Start** from the appropriate **Targeting Motorola DSP568xx Platform** documentation.

For example, the **Targeting Motorola DSP56852 Platform** manual provides more specific information and examples about this hardware architecture. If you are developing an application for an DSP56852EVM board or any other DSP56852 development system, refer to the **Targeting Motorola DSP56852 Platform** manual for **Quick Start** or other DSP56852-specific information.

Note: "DSP568xx" refers to the specific device for which you're developing, as shown in the preceding example.

1.2 Overview of Noise Suppression

1.2.1 Background

The Noise Suppression Library improves the overall quality of the desired speech signal by filtering out the background noise. This speech enhancement process is particularly necessary in environments having abnormally high levels of ambient background noise, such as an aircraft, a moving vehicle, or a noisy factory.

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Motorola's Noise Suppression Library works in the frequency domain and performs speech quality enhancement by spectral gain modification. The speech signal is high-pass filtered and transformed into frequency domain using FFT. Noise is estimated and cancelled in the frequency domain. The noise-cancelled frequency domain signal is transformed back to time domain using IFFT as depicted in **Figure 1-1**.

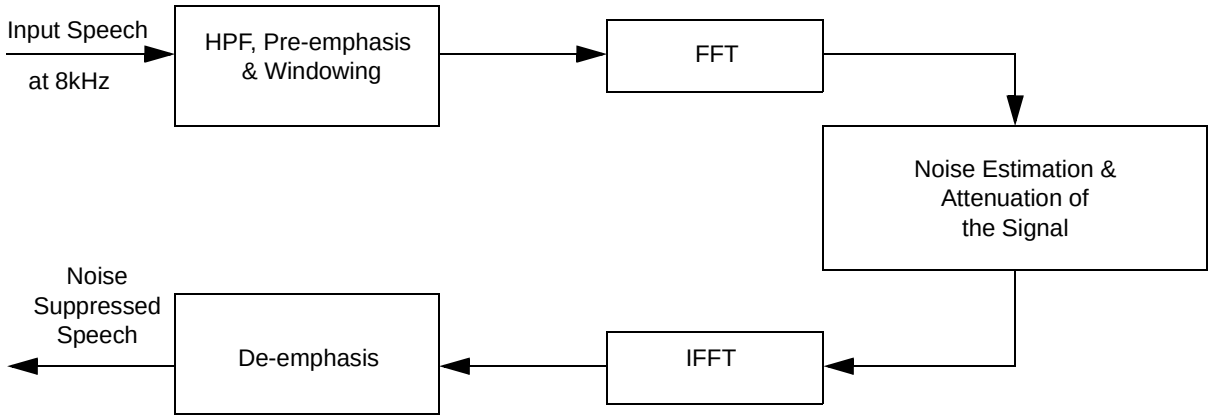

Figure 1-1. Functional Blocks of Noise Suppression library

1.2.2 Features and Performance

The Noise Suppression Library is multichannel and re-entrant.

For details on Memory and MIPS for a particular DSP, refer to the **Libraries** Chapter of the appropriate Targeting manual.

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Chapter 2
Directory Structure

Note: "DSP568xx" refers to the specific device for which you're developing, as shown in **Chapter 1, "Introduction."**

2.1 Required Core Directories

Figure 2-1 details required platform directories:

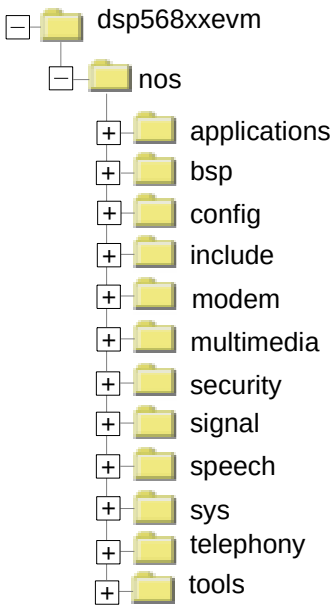

Figure 2-1. Core Directories

In this example, the DSP568xxEVM has no operating system (nos) support. This platform contains the following core directories:

- ***applications*** contains applications software that can be exercised on this platform
- ***bsp*** contains board support package specific for this platform
- ***config*** contains default hardware and software configurations for this platform
- ***include*** contains SDK header files which define the Application Programming Interface
- ***sys*** contains required system components
- ***tools*** contains utilities used by system components

Also, there are optional directories that include domain-specific libraries.

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2.2 Optional (Domain-Specific) Directories

Figure 2-2 demonstrates how the Noise Suppression algorithm is encapsulated in the domain-specific directories under the directory *telephony*, which includes telephony-specific algorithms.

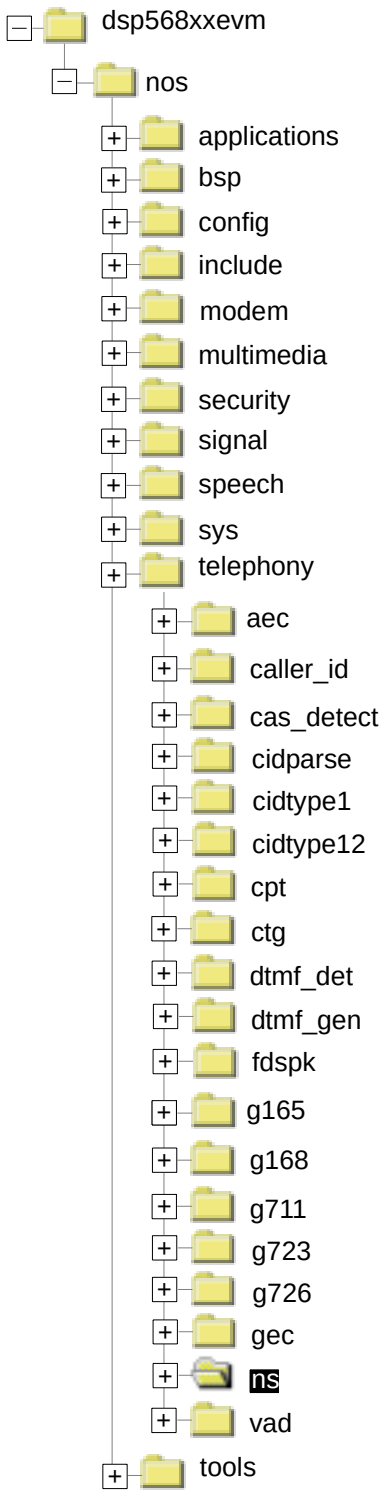

Figure 2-2. Telephony Directory Structure

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Figure 2-3 shows the *ns* directory structure under *telephony* directory.

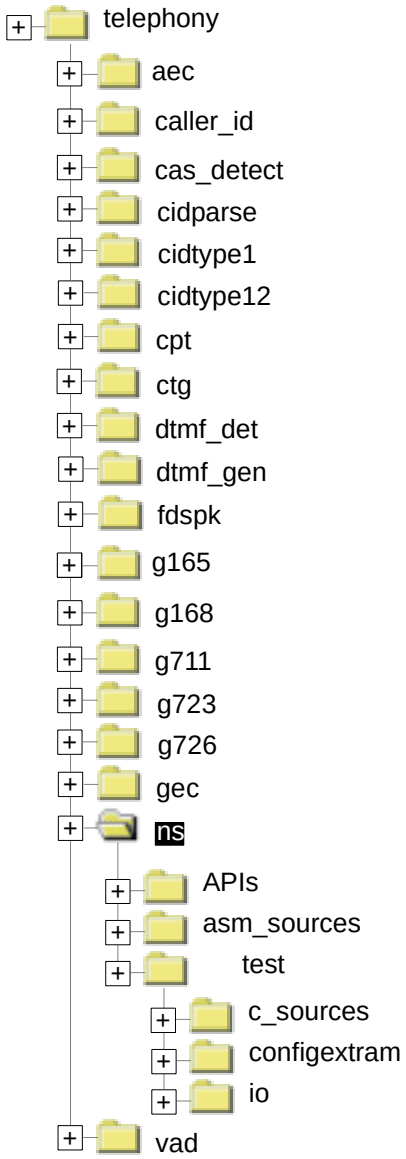

Figure 2-3. *ns* Directory Structure

The *ns* directory includes the following sub-directories:

- ***asm_sources*** includes all asm sources required for Noise Suppression
- ***c_sources*** includes APIs for Noise Suppression
- ***test*** includes C sources and configuration necessary for testing Noise Suppression library modules
  - — ***c_sources*** contains a sample test code
  - — ***configextram*** contains configuration files *appconfig.c*, *appconfig.h* and *linker.cmd* specific to Noise Suppression
  - — ***io*** contains input and reference test files

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The *applications* directory includes high-level software that exercises the Noise Suppression Library. As shown in **Figure 2-4**, the *applications* directory contains the *ns* application under *telephony*.

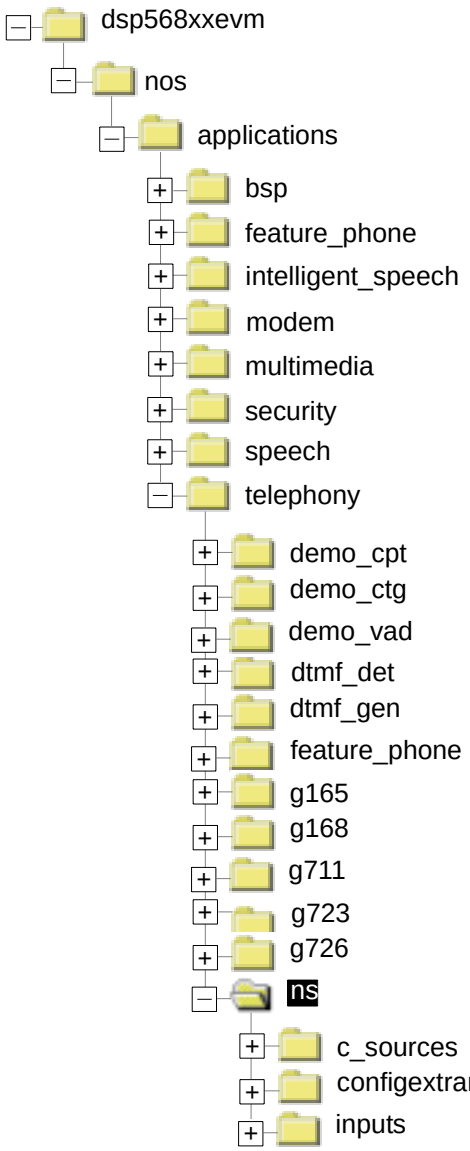

Figure 2-4. Noise Suppression Application

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Chapter 3
Noise Suppression Library Interfaces

3.1 Noise Suppression Services

The NS library cancels noise from the speech signal. The data to be supplied must be in 16 bit word, fixed point (1.15) format, as shown below:

i = information bit
s = sign bit

3.2 Interface

The C interface for Noise Suppression services is defined in the C header file *ns.h*, shown in **Code Example 3-1**.

Code Example 3-1. C Header File *ns.h*

```
#ifndef __NS_H
#define __NS_H

/*
   This include file is the master include file for the
   Noise Suppression. The applications using NS
   should include this file
*/

/***************************
 Foundational Include Files
***************************/
```


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```
#include "port.h"


/************************
 Flags
 ************************/

#define NS_HPF_ON  1
#define NS_HPF_OFF 0

/*****************************************
     Structure for NS
*****************************************/

/* Callback structure */

typedef struct
{
    void (*pCallback) (void *pCallbackArg, Word16 *pSamples,
                       UWord16 NumSamps);
    void *pCallbackArg;
} ns_sCallback;


/* User configurable structure */

/* This structure has to be used by the user
 * to configure NS */

typedef struct
{
    ns_sCallback Callback;
} ns_sConfigure;

/* Definitions for Noise suppression used in the create function */

#define NS_NUM_CHANNEL 16
#define NS_DELAY 24
#define NS_FFT_LEN 64
#define NS_FRM_LEN 80

/* NS handle structure */

/* This structure is used internally by NS for its
 * operation. The user should not setup this structure */

typedef struct
{
    Word16 *ns_hpf_states;
    Word16 *ns_prev_ch_snr;
    Word16 *ns_window_overlap;
    Word16 ns_pre_emp_mem;
    Word16 *ns_buffer;
    long *ns_scratch_for_fft;
    Word16 ns_not_first;
```

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```
    Word16 ns_frame_cnt;
    long *ns_ch_enrg;
    long *ns_ch_noise;
    long ns_tce;
    long ns_tne;
    Word16 *ns_ch_snr;
    Word16 *ns_ch_noise_db;
    Word16 *ns_ch_enrg_db;
    Word16 *ns_ch_enrg_long_db;
    Word16 ns_update_counter;
    Word16 ns_vm_sum;
    Word16 ns_update_flag;
    Word16 ns_last_update_counter;
    Word16 ns_hyster_counter;
    Word16 *ns_ch_gain;
    Word16 ns_zflag;
    Word16 ns_ch_enrg_dev;
    Word16 *ns_overlap;
    Word16 ns_de_emp_mem;

    ns_sCallback *callback;
    Word16 *pContextBuf;
    UWord16 ContextLen;

} ns_sHandle;

/**************************
 Function Prototypes
**************************/

EXPORT ns_sHandle *nsCreate (ns_sConfigure *pConfig);
EXPORT Result nsInit (ns_sHandle *pNS, ns_sConfigure *pConfig);
EXPORT Result nsProcess (ns_sHandle *pNS,
                         Word16 *pSamples,
                         UWord16 NumSamples);
EXPORT void nsDestroy (ns_sHandle *pNS);

#endif
```

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3.3 Specifications

The following pages describe the Noise Suppression Library functions.

Function arguments for each routine are described as *in*, *out*, or *inout*. An *in* argument means that the parameter value is an input only to the function. An *out* argument means that the parameter value is an output only from the function. An *inout* argument means that a parameter value is an input to the function, but the same parameter is also an output from the function.

Typically, *inout* parameters are input pointer variables in which the caller passes the address of a pre allocated data structure to a function. The function stores its results within that data structure. The actual value of the *inout* pointer parameter is not changed.

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3.3.1 *nsCreate*

Call(s):

```
ns_sHandle *nsCreate (ns_sConfigure *pConfig)
```

Required Header: *ns.h*

Arguments:

Table 3-1. *nsCreate* Arguments

pConfig	*in*	Points to configuration data for Noise Suppression

Description: The *nsCreate* function creates an instance of Noise Suppression. The *pConfig* argument points to the *ns_sConfigure* structure, which configures the Noise Suppression operation. For additional information, see *nsInit*, **Section 3.3.2**. Multiple instances are possible. During the *nsCreate* call, any dynamic resources required by the Noise Suppression algorithm are allocated; each call of *nsCreate* allocates 567 words of external data memory and 86 words of internal data memory. The library allocates dynamic memory using the *mem* library routines shown in **Code Example 3-2**.

Code Example 3-2. *mem* Library

```
#include "ns.h"
#include "mem.h"

ns_sHandle *nsCreate (ns_sConfigure *pConfig)
{
      ns_sHandle *pNS;
      bool   memflag = true;
      Result res;

      /* Memory allocation for Handle */
      pNS = (ns_sHandle *) memMallocEM (sizeof (ns_sHandle));
      if (pNS == NULL) return (NULL);

      /* Filter states buffer */
      pNS->ns_hpf_states = (Word16 *) memMallocIM (6 * sizeof (Word16));
      memflag = memflag & memIsIM (pNS->ns_hpf_states);

pNS->ns_prev_ch_snr =
      Word16 *) memMallocEM (NS_NUM_CHANNEL * sizeof (Word16));

pNS->ns_window_overlap =
      Word16 *) memMallocEM (NS_DELAY * sizeof (Word16));

pNS->ns_buffer =
      (Word16 *) memMallocEM (2 * NS_FFT_LEN * sizeof (Word16));

pNS->ns_scratch_for_fft =
      (long *) memMallocEM (NS_FFT_LEN * sizeof (long));
```

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```
pNS->ns_ch_enrg =
      (long *) memMallocEM (NS_NUM_CHANNEL * sizeof (long));

pNS->ns_ch_noise =
      (long *) memMallocEM (NS_NUM_CHANNEL * sizeof (long));

pNS->ns_ch_snr =
      (Word16 *) memMallocEM (NS_NUM_CHANNEL * sizeof (Word16));

pNS->ns_ch_noise_db =
      (Word16 *) memMallocEM (NS_NUM_CHANNEL * sizeof (Word16));

pNS->ns_ch_enrg_db =
      (Word16 *) memMallocEM (NS_NUM_CHANNEL * sizeof (Word16));

pNS->ns_ch_enrg_long_db =
      (Word16 *) memMallocEM (NS_NUM_CHANNEL * sizeof (Word16));

pNS->ns_ch_gain =
      (Word16 *) memMallocEM (NS_FFT_LEN * sizeof (Word16));

pNS->ns_overlap =
      (Word16 *) memMallocEM ((2 * NS_FFT_LEN - NS_FRM_LEN) * sizeof (Word16));

pNS->callback =
      (ns_sCallback *) memMallocEM (sizeof (ns_sCallback));

pNS->pContextBuf =
      (Word16 *) memMallocIM (NS_FRM_LEN * sizeof (Word16));
          memflag = memflag & memIsIM (pNS->pContextBuf);

if ((memflag == false) || (pNS->ns_hpf_states == NULL) ||
      (pNS->ns_prev_ch_snr == NULL) || (pNS->ns_window_overlap == NULL) ||
      (pNS->ns_buffer == NULL) || (pNS->ns_scratch_for_fft == NULL) ||
      (pNS->ns_ch_enrg == NULL) || (pNS->ns_ch_noise == NULL) ||
      (pNS->ns_ch_snr == NULL) || (pNS->ns_ch_noise_db == NULL) ||
      (pNS->ns_ch_enrg_db == NULL) || (pNS->ns_ch_enrg_long_db == NULL) ||
      (pNS->ns_ch_gain == NULL) || (pNS->ns_overlap == NULL) ||
      (pNS->callback == NULL) || (pNS->pContextBuf == NULL))
{
      nsDestroy (pNS);
      return (NULL);
}

      res = nsInit (pNS, pConfig);
      return (pNS);
}
```

For details on the *ns_sHandle* structure, please refer to **Code Example 3-1**. The *pConfig* argument points to the *ns_sConfigure* structure, which configures the Noise Suppression operation as shown in **Code Example 3-3**.

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If the *nsCreate* function is called to create an instance, then *nsDestroy*, **Section 3.3.4**, should be used to destroy the instance.

Alternatively, the user can allocate memory statically, which requires duplicating all statements in the *nsCreate* function. In this case, the user can call the *nsInit* function directly, bypassing the *nsCreate* function. If the user dynamically allocates memory without calling *nsCreate*, then the user himself must destroy the memory allocated.

Returns: Upon successful completion, the *nsCreate* function will return a pointer to the specific instance of Noise Suppression created. If *nsCreate* is unsuccessful for any reason, it will return "NULL".

Special Considerations:

- The Noise Suppression application is multichannel and re-entrant
- If *nsCreate* is called, then the user need not call the *nsInit* function, which is called internally in the *nsCreate* function

Code Example: In **Code Example 3-3**, the application creates an instance of Noise Suppression.

Code Example 3-3. Use of the *nsCreate* Interface

```
#include "assert.h"
#include "mem.h"
#include "ns.h"

#define FRAME_LEN     80

Word16 input_sample[FRAME_LEN];
Word16 output_sample[FRAME_LEN];

/* Function prototype */
void Callback (void *pCallbackArg, Word16 *pSamples, UWord16  NumSamples);

void main (void)
{
    ns_sHandle *pNS;
    ns_sConfigure *pConfig;
    Result res;

    /* Memory allocation */
    pConfig = (ns_sConfigure *) memMallocEM (sizeof (ns_sConfigure));
    if (pConfig == NULL)
        assert (!"Out of Memory");

    /* Initialize pConfig structure for Noise Suppression */
    pConfig->Callback.pCallback = Callback;
    pConfig->Callback.pCallbackArg = NULL;

    /* NS handle instance */
    pNS = nsCreate (pConfig);
    if (pNS == NULL) assert (!"Out of Memory");
```


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```
    /* Get FRAME_LEN number of samples into input_sample buffer */
    res = nsProcess (pNS, input_sample, FRAME_LEN);

    nsDestroy (pNS);
    if (res == FAIL) assert (!"Buffers could not be flushed");

    memFreeEM (pConfig);
    return;
}


void Callback (void *pCallbackArg, Word16 *pSamples, UWord16
              NumSamples)

{
    int i;
    for (i = 0; i < NumSamples; i++)
      output_sample[i] = pSamples[i]; /* Copy NS output into output
                                         buffer */
}
```

For details about structures used in **Code Example 3-3**, see **Code Example 3-1**.

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3.3.2 *nsInit*

Call(s):

```
Result nsInit (ns_sHandle *pNS, ns_sConfigure *pConfig);
```

Required Header: *ns.h*

Arguments:

Table 3-2. *nsInit* Arguments

pNS	*in*	Handle to an instance of Noise Suppression
pConfig	*in*	A pointer to a data structure containing data for initializing the Noise Suppression algorithm

Description: The *nsInit* function will initialize the Noise Suppression algorithm. During initialization, each resource will be set to its initial values in preparation for the Noise Suppression operation. Before calling the *nsInit* function, a Noise Suppression instance must be created, either by calling the *nsCreate* function (see **Section 3.3.1**), or by statically allocating memory, which does not require calling the *nsCreate* function.

The parameter *pConfig* points to a data structure of type *ns_sConfigure*; its fields initialize Noise Suppression operation in the following manner:

Callback - A structure of type *ns_sCallback*. It describes the procedure which Noise Suppression will call once a valid output data is available. The callback procedure has the following declaration:

```
void Callback (void *pCallbackArg, Word16 *pSamples,
                    UWord16  NumSamples);
```

The callback procedure parameter, *pCallbackArg*, is supplied by the user in the `ns_sCallback` structure; this value is passed back to the user during the call to the callback procedure. Typically, *pCallbackArg* points to context information used by the callback procedure, which the user must write. *pSamples* is a pointer to noise-suppressed data passed during a call to the *Callback* function from the *nsProcess* function. *NumSamples* is the length of noise-suppressed data in words.

A sample callback procedure is shown in **Code Example 3-4** as a reference; you must write your own callback procedure. This callback procedure processes the result as specified by the user. The simplest method may be to copy the result into an output buffer, as shown in **Code Example 3-4**.

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Code Example 3-4. Sample Callback Procedure

```
void Callback (void *pCallbackArg, Word16 *pSamples, UWord16
                    NumSamples)
{
       int i;
       for (i = 0; i < NumSamples; i++)
       output_sample[i] = pSamples[i]; /* Copy NS output into output
                                          buffer */

}
```

The *output_sample* buffer could be as defined in **Code Example 3-3**.

Returns: Upon successful completion, a value of “PASS” will be returned; otherwise, a value of “FALSE” will be returned.

Special Considerations:

- If *nsCreate* is called, then the user need not call the *nsInit* function, which is called internally in the *nsCreate* function

Code Example: In **Code Example 3-5**, the application creates an instance of Noise Suppression. The instance is passed to *nsInit* along with the Noise Suppression configuration structure *pConfig*.

Code Example 3-5. Use of *nsInit* Interface

```
#include "ns.h"
...

Note: This example shows the use of nsInit function when the user does not use
nsCreate function.

#define FRAME_LEN 80

...

ns_sConfigure  pConfig;
ns_sHandle  pNS;

/* Noise Suppressor Data */

Word16 ns_hpf_states[6];
Word16 ns_prev_ch_snr[NS_NUM_CHANNEL];
Word16 ns_window_overlap[NS_DELAY];
Word16 ns_buffer[2 * NS_FFT_LEN];
long ns_scratch_for_fft[NS_FFT_LEN];
long ns_ch_enrg[NS_NUM_CHANNEL];
long ns_ch_noise[NS_NUM_CHANNEL];
Word16 ns_ch_snr[NS_NUM_CHANNEL];
Word16 ns_ch_noise_db[NS_NUM_CHANNEL];
```


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```
Word16 ns_ch_enrg_db[NS_NUM_CHANNEL];
Word16 ns_ch_enrg_long_db[NS_NUM_CHANNEL];
Word16 ns_ch_gain[NS_FFT_LEN];
Word16 ns_overlap[(2 * NS_FFT_LEN - NS_FRM_LEN)];
Word16 Context_buff[NS_FRM_LEN];

...

void main()
{
    Result  res;
    ns_sCallback callback_instance;
    ...

    /* Instance of NS */

    pNS.ns_hpf_states = ns_hpf_states;
    pNS.ns_prev_ch_snr = ns_prev_ch_snr;
    pNS.ns_window_overlap= ns_window_overlap;
    pNS.ns_buffer = ns_buffer;
    pNS.ns_scratch_for_fft = ns_scratch_for_fft;
    pNS.ns_ch_enrg = ns_ch_enrg;
    pNS.ns_ch_noise = ns_ch_noise;
    pNS.ns_ch_snr = ns_ch_snr;
    pNS.ns_ch_noise_db = ns_ch_noise_db;
    pNS.ns_ch_enrg_db = ns_ch_enrg_db;
    pNS.ns_ch_enrg_long_db = ns_ch_enrg_long_db;
    pNS.ns_ch_gain = ns_ch_gain;
    pNS.ns_overlap = ns_overlap;
    pNS.pContextBuf = Context_buff;

    /* Initialize pConfig structure for Noise Suppression */
    callback_instance.pCallback = Callback;
    callback_instance.pCallbackArg = NULL;
    pConfig.Callback = callback_instance;

    /* Call to Noise Suppression Init */
    res = nsInit(&pNS, &pConfig);
    ...
    ...
}
```

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3.3.3 *nsProcess*

Call(s):

```
Result nsProcess (ns_sHandle *pNS, Word16 *pSamples, UWord16 NumSamples);
```

Required Header: *ns.h*

Arguments:

Table 3-3. *nsProcess* Arguments

pNS	*in*	Handle to an instance of Noise Supression
pSamples	*in*	Pointer to the input sample buffer
NumSamples	*in*	Number of samples in the input buffer

Description: The *nsProcess* function suppresses noise on the input samples. It calls the *Callback* function once a valid output is available. The user can call the *nsProcess* function any number of times, as long as there is data.

Returns: Upon successful completion, *nsProcess* returns “PASS”; if there is any error, *nsProcess* returns “FAIL”.

Special Considerations: None

Code Example: See **Code Example 3-3** to learn how to use the *nsProcess* function.

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3.3.4 *nsDestroy*

Call(s):

```
void nsDestroy (ns_sHandle *pNS);
```

Required Header: *ns.h*

Arguments:

Table 3-4. *nsDestroy* Arguments

pNS	*in*	Handle to an instance of Noise Suppression generated by a call to *nsCreate*

Description: The *nsDestroy* function destroys the instance of Noise Suppression originally created by a call to *nsCreate* function.

Returns: None

Special Considerations: Calling the *nsDestroy* function frees the memory allocated during the *nsCreate* function. The *nsDestroy* function should only be called if the *nsCreate* function was used to create the instance. If user created the instance himself, bypassing the *nsCreate* function, then the user himself must free the memory.

Code Example: See **Code Example 3-3** to learn how to use the *nsProcess* function.

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Chapter 4
Building the Noise Suppression Library

4.1 Building the Noise Suppression Library

The Noise Suppression Library combines all of the components described in previous sections into one library: *ns.lib*. To build this library, a Metrowerks' CodeWarrior project, *ns.mcp*, is provided. This project and all the necessary components to build the Noise Suppression library are located in the ***...\nos\telephony\ns*** directory of the SDK directory structure.

There are two methods to execute a system library project build: dependency build and direct build.

4.1.1 Dependency Build

Dependency build is the easiest approach and requires no additional work on the user's part. If you add the Noise Suppression library project, *ns.mcp*, to your application project, as shown in **Figure 4-1**, the Noise Suppression Library will automatically build when the application is built.

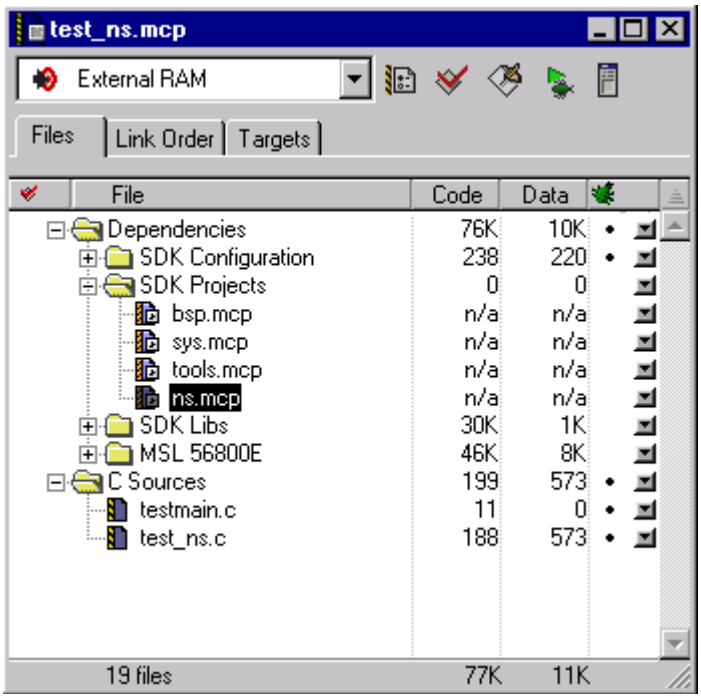

Figure 4-1. Dependency Build for the Noise Suppression Library

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4.1.2 Direct Build

Direct build allows you to build a Noise Suppression Library independently of any other build. Follow these steps:

Step 1. Open *ns.mcp* project, as shown in **Figure 4-2**.

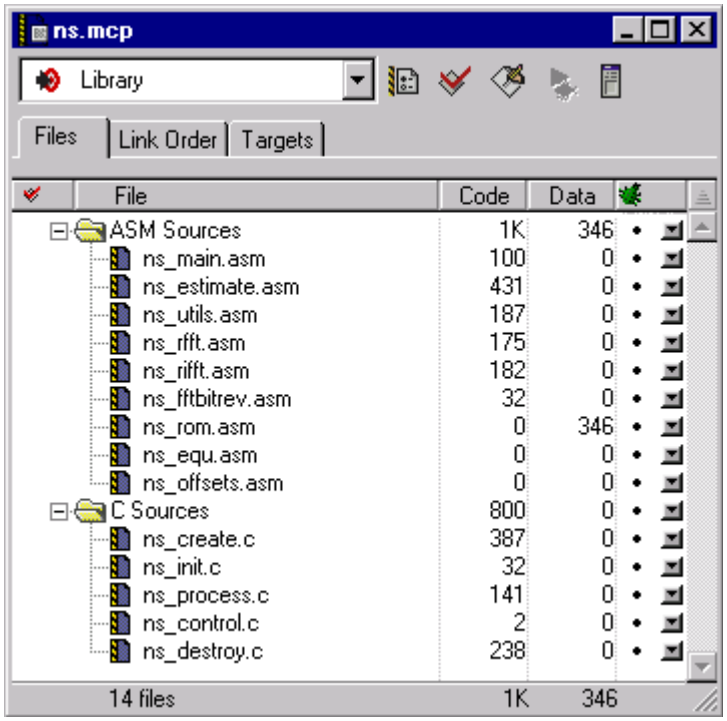

Figure 4-2. *ns.mcp* Project

Step 2. Execute the build by pressing function key [F7] or by choosing the *Make* command from the *Project* menu; see **Figure 4-3**.

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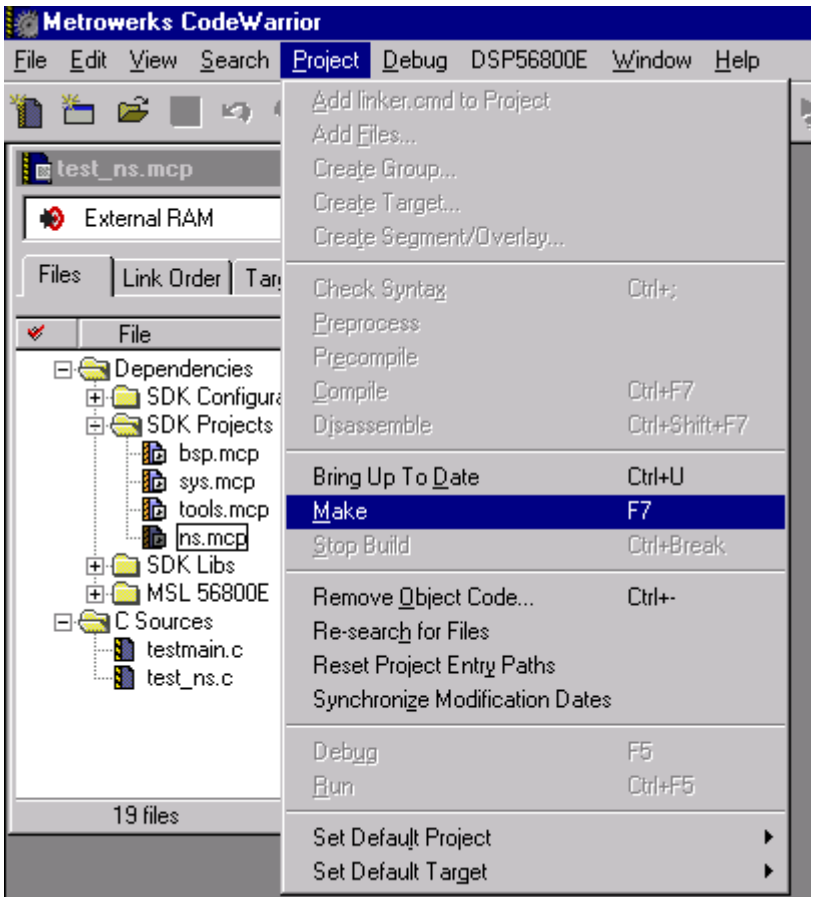

Figure 4-3. Execute Make

At this point, if the build is successful, an *ns.lib* library file is created in the **...\nos\telephony\ns\Debug** directory.

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Chapter 5
Linking Applications with the Noise Suppression Library

5.1 Noise Suppression Library

The Noise Suppression Library includes APIs, which provide an interface between the user application and the Noise Suppression modules. To invoke Noise Suppression, APIs must be called in this order:

nsCreate (.....);

nsInit (.....);

nsProcess (.....);

nsDestroy (.....);

For details on the Noise Suppression interface, see **Chapter 3**.

5.1.1 Library Sections

The Noise Suppression Library contains the following data ROM section that must be placed in **internal** memory through the linker command file:

NS_ROM: This section contains the high pass filter coefficients for Noise Suppression.

Code Example 5-1 shows a sample *linker.cmd* file, which may be used in testing the Noise Suppression library.

Code Example 5-1. *linker.cmd* File

```
#*****************************************************************************
#
# Linker.cmd file for DSP56852 External RAM
#    using only external program and data memory.
#
#*****************************************************************************

MEMORY {
```


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```
      .pInterruptVector   (RWX) : ORIGIN = 0x000000, LENGTH = 0x000082
      .pIntRAM            (RWX) : ORIGIN = 0x000082, LENGTH = 0x00177e
      .pExtRAM            (RWX) : ORIGIN = 0x001800, LENGTH = 0x1EE800
      .pIntROM            (RX)  : ORIGIN = 0x1F0000, LENGTH = 0x000400
      .xIntRAM            (RW)  : ORIGIN = 0x000100, LENGTH = 0x000700
      .xIntRAM_DynamicMem (RW)  : ORIGIN = 0x000800, LENGTH = 0x000800
      .xStack             (RW)  : ORIGIN = 0x001000, LENGTH = 0x000800
      .xExtRAM_DynamicMem (RW)  : ORIGIN = 0x001800, LENGTH = 0x001000
      .xExtRAM            (RW)  : ORIGIN = 0x002800, LENGTH = 0x1FD400
      .xPeripherals       (RW)  : ORIGIN = 0x1FFC00, LENGTH = 0x000400
      .xExtRAM2           (RW)  : ORIGIN = 0x200000, LENGTH = 0xDFFF00
      .xCoreRegisters     (RW)  : ORIGIN = 0xFFFF00, LENGTH = 0x000100

}

#*****************************************************************************

FORCE_ACTIVE {FconfigInterruptVector}

#*****************************************************************************

SECTIONS {

   #*****************************************************************************

    .ApplicationInterruptVector :
             {
                   vector.c (.text)

             } > .pInterruptVector

   #*****************************************************************************

             .ApplicationCode :
             {
      # Place all code into Program RAM

                   * (.text)
                   * (rtlib.text)
                   * (fp_engine.text)
                   * (user.text)

                   # Place all data into Program RAM

                   F_Pdata_start_addr_in_ROM = 0;
                   F_Pdata_start_addr_in_RAM = .;
                      pramdata.c (.data)
                   F_Pdata_ROMtoRAM_length = 0;

                F_Pbss_start_addr = .;

                      _P_BSS_ADDR = .;
                      pramdata.c (.bss)

                   F_Pbss_length = . - _P_BSS_ADDR;

             } > .pExtRAM
```

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```
#*****************************************************************************

          .ApplicationData :
          {
                # Define variables for C initialization code

                F_Xdata_start_addr_in_ROM = .;
                F_StackAddr               = ADDR(.xStack);
                F_StackEndAddr = ADDR(.xStack) + SIZEOFW(.xStack) - 1;
                F_Xdata_start_addr_in_RAM = .;

                # Define variables for SDK mem library

                # Data (X) Memory Layout

                      _EX_BIT     = 0;

                   # Internal Memory Partitions (for mem.h partitions)

                      _NUM_IM_PARTITIONS = 1;  # IM_ADDR_1 (no IM_ADDR_2 )

                   # External Memory Partition (for mem.h partitions)

                      _NUM_EM_PARTITIONS = 1;   # EM_ADDR_1

                   FmemEXbit = .;
                      WRITEH(_EX_BIT);
                   FmemNumIMpartitions = .;
                      WRITEH(_NUM_IM_PARTITIONS);
                   FmemNumEMpartitions = .;
                      WRITEH(_NUM_EM_PARTITIONS);
                   FmemIMpartitionList = .;
                      WRITEH(ADDR(.xIntRAM_DynamicMem)*2);
                      WRITEH(SIZEOF(.xIntRAM_DynamicMem)*1);
                   FmemEMpartitionList = .;
                      WRITEH(ADDR(.xExtRAM_DynamicMem)*2);
                      WRITEH(SIZEOF(.xExtRAM_DynamicMem)*1);

                # Add rest of the data into External RAM

                   * (.const.data)
                   * (.data)
                   * (fp_state.data)
                   * (rtlib.data)

                F_Xdata_ROMtoRAM_length = 0;

                F_Xbss_start_addr = .;
                _X_BSS_ADDR = .;

                   * (rtlib.bss.lo)
                   * (rtlib.bss)
                   * (.bss)
```

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```
                F_Xbss_length = . - _X_BSS_ADDR;  # Copy DATA

        } > .xExtRAM

#*****************************************************************************

        .NS_ROM_Data :
        {
                #*************************
                # Noise suppression ROM data
                #*************************

                * (NS_ROM.data)
                * (NS_ROM.bss)

                #*************************

        } > .xIntRAM

        FArchIO             = 0x0000;
        FArchCore           = ADDR(.xCoreRegisters);
        FArchInterrupts     = ADDR(.pInterruptVector);

}
```

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Chapter 6
Noise Suppression Applications

6.1 Test and Demo Applications

To verify the Noise Suppression algorithm, test and demo applications have been developed. Refer to the **Targeting Motorola DSP568xx Platform** Manual for the DSP you are using to see if the test and demo applications are available for your target.

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Chapter 7
License

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Index

A

API x
    Application Programming Interface x
asm_source 2-3

C

c_sources 2-3
COM1 x
    Communication Port 1 x

D

Dependency Build 4-1
Direct Build 4-2
DSP x
    Digital Signal Processor x

E

EVM x
    Evaluation Module x

F

FFT xi
    Fast Fourier Transforms xi
FIR xi
    Finite Impulse Response xi

G

G.165 Services 3-1
g165Create 3-5
g165Init 3-9
g165Process 3-12

H

HPF xi
    High-Pass Filter xi

I

I/O xi
    Input/Output xi
IDE xi
    Integrated Development Environment xi
IFFT xi
    Inverse Fast Fourier Transform xi
IIR xi
    Infinite Impulse Response xi
IRQA xi
    Interrupt Request A xi

L

Linking Applications 5-1

M

MAC xi
    Multiply/Accumulate xi
Metrowerks CodeWarrior 4-1
MIPS xi
    Million Instructions Per Second xi
MSB xi
    Most Significant Bit xi

N

NS xi
    Noise Suppression xi

O

OMR xi
    Operating Mode Register xi
OnCE xi
    On-Chip Emulation xi

P

PC xi
    Program Counter xi

S

SDK xi
    Software Development Kit xi
SNR xi
    Signal-to-Noise Register xi
SP xi
    Stack Pointer xi
SPI xi
    Serial Peripheral Interface xi
SR xi
    Status Register xi
SRC xi
    Source xi

T

telephony 2-2
    algorithms 2-2
test_g165 2-3

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